Invited Paper

Holographic features in security printing and the human face in currency printing

Gilbert Colgate, Jr.,
American Bank Note Company
New York, New York

ABSTRACT

In security printing in general and currency printing in particular, it is very rare for a single security feature to carry the total burden of "authenticity." There is almost always a layering of features, which in their complexity and coherence eventually determine the genuine. We give examples to show holography is no exception to the rule of layering. After discussing the integration of various layered holographic features into a security product, the paper discusses currency, proposing authentication of currency is, today, fundamentally a human perception and that the human eye is more attuned to recognition of a face than a machine readable random pattern.

key words: security printing, holography, authentication, currency, human face.

1. DESIGN ASPECTS OF SECURITY HOLOGRAMS

1.1 History

Only fifteen years ago, the creation of an embossed hologram was a considerable mystery and the ability to make one shrouded in secrecy. Like ancient silk, examples were precious. Eventually the silk worm was exported, or, in this case returned from whence it had come. Then, quite suddenly, there were numerous holographers capable of making and embossing simple 2D/3D holograms. Consequently it became evident we needed to increase the difficulty of compromising a hologram if holography was to continue its extraordinary value in security printing.
It should be obvious that in security printing and in currency printing in particular, no single security feature bears the entire burden of providing authenticity. The security features are layered and interwoven so that the final product becomes a complex but coherent work of art, difficult for the counterfeiter to replicate or compromise. Holography proved no exception to this rule.

Enter ABNH's chief holographer, Lily Sun O'Boyle, protege of Ken Haines who much earlier had won the battle with Steve McGrew (and me) to author the VISA Dove. Lily has earned a reputation as one of the world's great holographers, and is without doubt the reason why ABNH maintains its reputation for making consistent holograms of extremely fine quality. It is Lily who has pioneered many of the techniques, the results of which we will show you today. I believe she is sufficiently modest to admit she has gathered around her a talented and dedicated staff and has been blessed with extremely fine optical equipment, without which much of what she has accomplished would not be possible. But it is Lily who has mastered the techniques of creating a "security hologram" from an ordinary embossed hologram. Occasionally we have referred to them as "Supergrams" but for our purposes today we simply call them security holograms.

1.2 Security levels

In some cases, most often as a label, the hologram alone became the "security device". It alone bore the entire burden of providing authenticity to the article to which it is attached. Thus exposed, it became obvious to ABNH that a layered approach to holographic security was required.

I believe the first holographic security label was made in 1980. It was a 2D/3D label by U.S. Banknote. Steve McGrew was the holographer working from flat art and the embossing was done by Hugh Wynd at The Diffraction Company.

0-8194-2033-6/96/$6.00

* The first level of additional security became known as the "flip" image. The flip image can be superimposed over the entire primary image.
* The next layer or level is using full color holograms. Assuming the counterfeiter is trying to "knock off" an image and replicate it, the use of full color and the attendant complexities eliminate a number of potential counterfeiters.
* An additional level is the use of moving elements, and parallax.
* An even further level of security is micro engraved text, such as in the waterline of a boat on an image element of a particular security hologram, which can be read only with a magnifying glass. With the naked eye such micro engraved text just looks like a bright line.
* To further improve the hologram from contact copying and other fraud, there is a dot-matrix hologram included with the more traditional hologram. This dot-matrix provides an effect almost identical to the kinegram and is very bright.
* If that were not enough layering, the hologram is further "partially demetalized." This is not a holographic feature, but it is very definitely a security feature and it and its use is well patented by ABNH.
* Finally, ABNH has created several ways to machine read the hologram. The invisible holographic bar code is a patented feature.

Thus layering comes to the hologram, the holographic label and to the product it serves to authenticate.
To recapitulate the various items that provide layering:
- Flip image
- Color
- Parallax
- Micro-engraving
- Dot-matrix
- De-metalization
- Machine readability

In the interests of protecting ABNH's intellectual property, the foregoing is only a partial list of how ABNH keeps ahead. Another technique, not used extensively, but available is the double hologram, one first order reconstruction at a 90 degrees rotation to the other.

1.3 Holographic originations and copies

We are not claiming that no one else could make a complex security hologram. The Chinese Optical Society (CHIOPS) invitation for the conference in Nanjing this August contains an extremely well done hologram which has color and parallax and flip image. While it does not have micro engraving, dot matrix, nor machine readability I do not put it outside the limits of a first rate holographic lab to introduce those features.

But, and this is very important, the creation of two identical holograms is an order of magnitude more difficult than the creation of one. If ABNH were tasked to replicate the CHIOPS hologram - from scratch, I am not ashamed to admit we would find it difficult enough to create a look-a-like and almost impossible to recreate one which is absolutely the same. While, in the case of this hologram we could contact copy, ABNH makes certain that security holograms are resistant to such copying. Those techniques are proprietary, and cannot be discussed openly. Also, the ability to copy or create the optically variable device does not mean you can counterfeit a document any more than the ability to engrave a line means you can counterfeit currency.

Again, we turn to the laboratory and find there the ability to copy kinegrams and pixelgrams. A demonstration of the ability to copy OVDs is given by using the appendix page A3 from the book Optical Document Security.[1] This appendix page contains a specimen of a kinegram and of a pixelgram. Laboratory practice shows that it does not take more than 45 minutes to make holographic copies of such features.
But that is not the point. That is like saying, anyone with a camera can counterfeit a currency, or anyone with an engraving tool and a plate of metal can make the plates and counterfeit a currency. While it's true all you need is a metal plate and an engraving tool and if you have the skill and time, you might engrave an absolutely perfect counterfeit of a bill, providing you have the paper, likewise the inks, and the intaglio press.

Your ability to engrave does not make steel plate engraving obsolete, nor does the ability to make holograms, or pixelgrams or kinegrams make their use in security printing and especially in currency obsolete. Again we must consider the layering phenomena.

1.4 The Significance of the Human Face

In 560 BC Croesus had the likeness of his face stamped onto the gold coins in use in those days. While, within the year, criminals were shaving the edges of the legitimate coins the old King started a "policy" if you will that exists to this day.
A demonstration of the human ability to recognize faces was given during the presentation of this paper by projecting, for the duration of a split second, a slide which displayed a banknote containing the face of Mickey Mouse. From the reaction of the audience it was obvious that, in spite of the extremely short display time, the recognition was immediate.

To this day, faces appear on currency. In part it is felt the prominence of the face lends confidence and authenticity to the value of the currency upon which the portrait is placed. Truly money is, at root, only the confidence in its value. Otherwise it reverts to it's extrinsic value. Wampum is but a purple clam shell - how can it be otherwise we say? But, at one time it had the value of our $100 bills. The use of a person's face is on all types of currency, from Presidents, Kings and Queens and Dictators. Particularly appealing to me is this one of Lenin. He not only took over the five ruble note but also the ten, twenty and fifty.
But why use the face? Why not use the printed name. Lenin says this piece of paper has value? Why not, significantly, the signature?
It may sound condescending, although it's not meant to be. Monarchs, from Croesus to the present day, believe subjects recognize them. Probably many subjects did indeed. I submit, through anecdotal evidence, the ability of humans to recognize faces is extraordinarily deep rooted in our psyche. Also in those days most people could not read or write and the signature was meaningless.

Each of us has to recognize other humans as friend or foe and we have to make the judgment with great speed. Our survival depends upon it. As babies we sought out our Mother's facial features. We recognized family about the age of two (before that there was only mommy and daddy). The French psychologist Piaget showed how goslings locked in and bonded permanently to the first "mother" to whom they were exposed, even if that mother turned out to be a male human. Our minds lock in on people and are refined through years of training. Most people have two eyes, a nose and a mouth, a certain amount of hair and a general coloration. How is it that we can look at 500 humans and almost instantly pick out a wife, parent or child. All humans look pretty much alike in a crowded train station.

This is not the forum to attempt to prove facial features are a determinant security feature for currency printing. What with the camera, a portrait can be "copied" rather easily, although prior to the camera hardly at all. Yet, since most currency transactions are handled by humans, the instantaneous recognition of that currency is an important element in its acceptance. If you were a bartender in London I think you would recognize the difference between various currencies with different portraits, rather quickly.

The New York Stock Exchange has a rule (501.1) re "vignettes" on stock certificates, says:
"*the design should afford the maximum protection against counterfeiting and, for this purpose, a human figure, with plainly discernible features and a minimum 3/4 frontal view of the face should be part of every vignette as a central figure.*"

From my own experience, I can recall when a clerk at a Woolworth's took a $10 bill and went to her supervisor before bringing me back the change: I asked her why did she suspect a counterfeit? "Because Hamilton had no eyebrows" she said. It was a lightly printed note and she was quite right. The eyebrows didn't show. Now you will notice a person without eyebrows, but you won't necessarily notice a few thin lines in the border of a banknote which are or are not there.
A demonstration to this effect was given during the presentation of this paper by projecting two glyphs, which contained very different messages. Glyphs are machine readable codes recently commercially offered by Xerox. Glyphs can follow a document around almost as a background image while directing Xerox color copiers to use appropriate colors even though the colored original has been sent over a black and white digital telephone line. Although some 80% of the actual information was rearranged from one glyph to another, the difference could obviously not be readily observed by the audience.

A further demonstration showed the human ability to easily discriminate between two faces in which only a very small percentage of the information was rearranged: one portrait without and one portrait with a beauty-spot.

2. PUBLIC ASPECTS OF CURRENCY

There are two public aspects that regard money which should be discussed in this context. The first is the enormous number of public cash transactions that takes place on a daily base. The second is the public confidence required for such transactions. It may be suspected that these two aspects are associated.

2.1 The Number of Public Cash Transactions

We are now back to currency and security printing, making sure that we incorporate a human face. And I have led you to believe that we will incorporate a holographic human face into currency. We may, but it is not important the face be holographic, only that a face be there. It is probable the face in currency will not be optically variable, because one can print such expressive faces by current means. But the increasing use of optically variable devices in currency is a foregone conclusion. The central banks must offer currency which defeats the color copier and color litho printer.

Approximately 90% of all commercial transactions in the world this year will be cash transactions. Practically all currency transactions interface with humans. Therefore human recognitions and acceptance of genuine currency is absolutely essential. It is the single most important aspect of currency.
The volume or value of these transactions will be minuscule compared to the value of wire transfers, check and credit card activity, but the number of transactions is nevertheless huge.
Understandably the figure 90% is not firm but here, in the United States, at least 70% of the transactions are cash. In many parts of the world the cash economy is virtually 100%. If all of us in the United States only had one cash transaction a day, there would be a quarter billion transactions a day and, every day someone has to count up all this money.

2.2 Security Features and Public Confidence

Your attention is invited to the last statement - someone has to count the money. Our grandchildren will bring up on their computer screens various old fashioned versions of money. They will bring up wampum, old gold coins, paper money and shake their heads in sadness and wonder that people back nowadays could be so stupid.
Imagine that people had to count the money when they took it, count it at the end of the day and send it physically to a bank. Then the bank had to count it again when it credited the account, and again when it transferred the cash out to some one else!

However, they will also admit that the root of money is the confidence of the people that whatever it is they use to effectively store wealth has the value imputed to it. It makes no difference what the money is, wampum, copper bracelets, paper currency or digicash. You must have confidence in it. That of course is where security printing comes in. Simply put: currency may be time consuming, uneconomical to make, store and dispose of, but it is accepted by the humans who use it. It cannot become too complicated because currency is handled by humans first and only secondarily by organizations with machine readable or other detecting equipment. It must be blatantly and immediately understood by people. You would think this is obvious, but all sorts of "solutions" to counterfeiting are suggested, some of which may be very elegant but often too fancy.

Many banknotes contain more than a half dozen security features. Such anticounterfeiting features are divided amongst the paper, the inks, in higher denominations the plastic thread, and the numbering and the taggants. However, in US currency the most significant anticounterfeiting burden is still carried by the intaglio printing. A good offset printed reproduction may not look very different, but it will feel different and because most money is handled by people, the chances of detecting counterfeits are increased.
The first conclusion is that - for paper money - intaglio or steel plate engraving will remain the printing method of choice.
We can assume, or conclude if you will, all currency is threatened by color copiers which get better every day, and eventually all currency will have to contain optically variable devices.

3. OPTICALLY VARIABLE INTEGRATED DEVICES

The term Optically Variable Integrated Device (OVID) was coined by Bruce Munch, Bill Green and Paul Jacob at Xerox's Special Information Systems Division in 1982.

The first optically variable integrated device was made by US Banknote Company in 1980 and obviously by American Bank Note Company in 1982 when the MasterCard holographic program began. The Hologram on the credit cards is, after all an OVID.

The early OVIDS were basically diffraction gratings. There was no particular security built into them other than the fact they were what they were. Until recently holograms, kinegrams and pixelgrams followed the same course. The attempt to incorporate them into a currency failed, I believe, because the results simply did not look good. If I were in the Bureau of Engraving and Printing at the time, I would not have accepted the results either. Thus some other representations of the OVID are being developed at ABNH. There are some proprietary concerns in the actual making of this material, and the nature of how we keep this material bright after 32 crumples in the dreaded crumpleometer, cannot be revealed in this forum. Another example of an OVID is found on the new Bulgarian 2000 Lev note. This OVID is further integrated in the banknote by printing the intaglio artwork over the OVID.

From the optical and holographic concern the importance is the integration of an holographically created OVID into the product, in such a way as to increase that product's resistance to the ubiquitous counterfeiter. From a practical view, human faces will remain on paper currency for the foreseeable future. However, the face probably will not be the optically variable device, although it may be, such as in the bicentennial Australian ten dollar bill that bears a portrait of Captain Cook. But most likely the optically variable features will perform the task which the guilloche or ornamental borders performed in intaglio. Intaglio will continue to be the choice for currency printing, because of the feel it imparts.

4. THE HOLOMAGNETIC STRIPE

When currency disappears in favor of electronic cash, since we well know the limits of encryption and decryption, we may see the appearance of an asymmetric key to the chip card, and the key may be formed in the following fashion. A magnetic card is provided with the Holomagnetic™ stripe and within the holography is a holographically created number.[2] The magnetics may read: Customer Jones, account number 1234. The machine readable hologram reads simply (for example) 5678. Check digit the results or encode them, take a numerical result, for example simply 123456782 and write that result to the EPROM of the chip.

Then when the card is used, the swipe reader which is now going to be able to read magnetics and the hologram, (with the addition of a laser diode) as well as the chip, first reads the magnetics, then the holographic number, and calculates what should be on the EPROM of the chip. When it finds the match it then proceeds to the transaction with the wealth which is stored in the chip.

Because this holographically based system incorporates a physical layer not digital electronics - it cannot be defeated by cryptography no matter how sophisticated.

5. CONCLUSION

In conclusion, it appears from where we view the commercial world there is going to be a significant place for holography in security printing in general and the field of currency in particular whether or not the currency is paper or electronic.

As to whether there will be a human face in electronic cash, that's for a presentation five years from now. If there is, it might be "Big Brother's" but I'm more inclined to believe it is more likely to be your own.

6. REFERENCES

1. R.L. van Renesse (ed.), *Optical Document Security*, Artech House, Boston/London 1993, ISBN 0-89006-619-1.
2. G. Colgate, The Holomagnetic Stripe, Reference 1, chapter 8.4.1.